Real-time Tracking for Assisted Living

By

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I. Abstract:

This paper is intended to explain and present our research on a real-time tracking and locating system for an indoor environment. The paper includes the description and implementation of each part of this system, and the result of the experiments that we have conducted on this system.

II. Introduction:

The main propose of our project is to help elders how live alone in their homes. Instead of making these elders stay in a hospital or under a medical surveillance, this system will keep monitoring their movement, behavior and any risk on their health, and feeds this information to a health association like hospital or clinic to alarm them if there is any danger on these elders' health. Also, this system will provide several useful tools like searching for lost object inside a house and reminding a person of his/her medicine time.

To achieve the previous goals, we have designed our system to perform an indoor real-time tracking for human and objects. The main system is divided into three subsystems as shown in figure 1, RFID subsystem for object positioning, Cricket subsystem for human tracking, and base station which includes the graphic user interface. Each one of these subsystems has its own components and configuration. The RFID subsystem will track the position of any object with a tag in a house using RFID reader and report this updated position readings to the base station. The cricket system will track the movement of any person in the house how is carrying a cricket component (listener), and also report the updated data to the base station. The base station role is just to gather the incoming data and pass it to the GUI (graphical user interface). The GUI function is to receive the data forwarded from the base station and simulate it on the screen in a graphical way, beside it will provide some useful tools which will help the user to search for there lost belongings and will reminds the user of his medicine time.

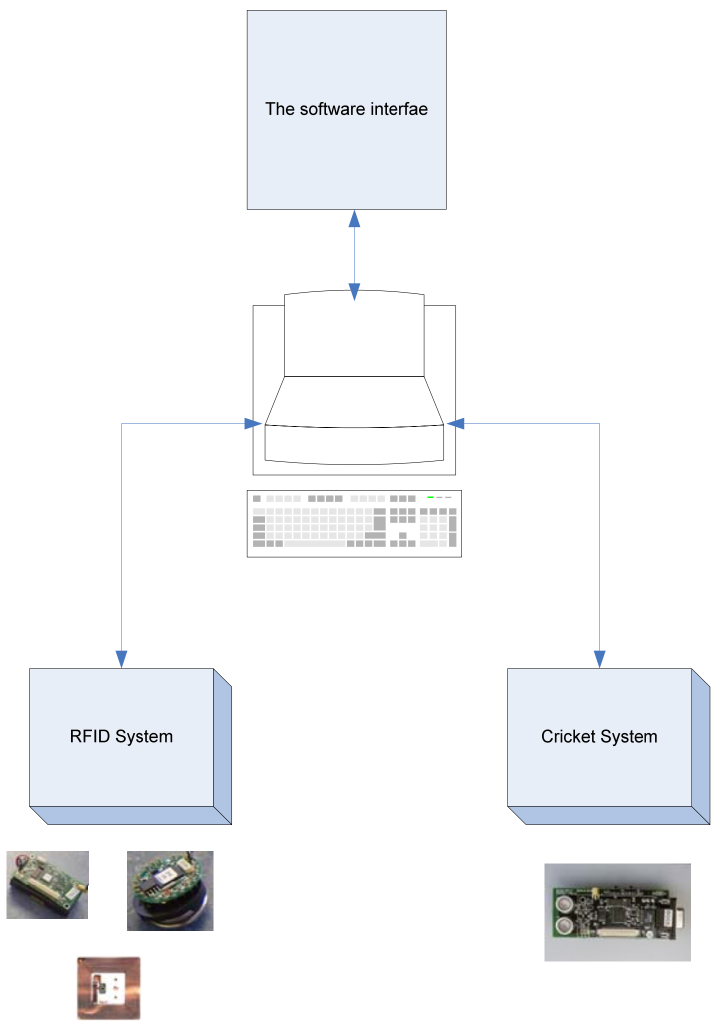

Figure 2.1

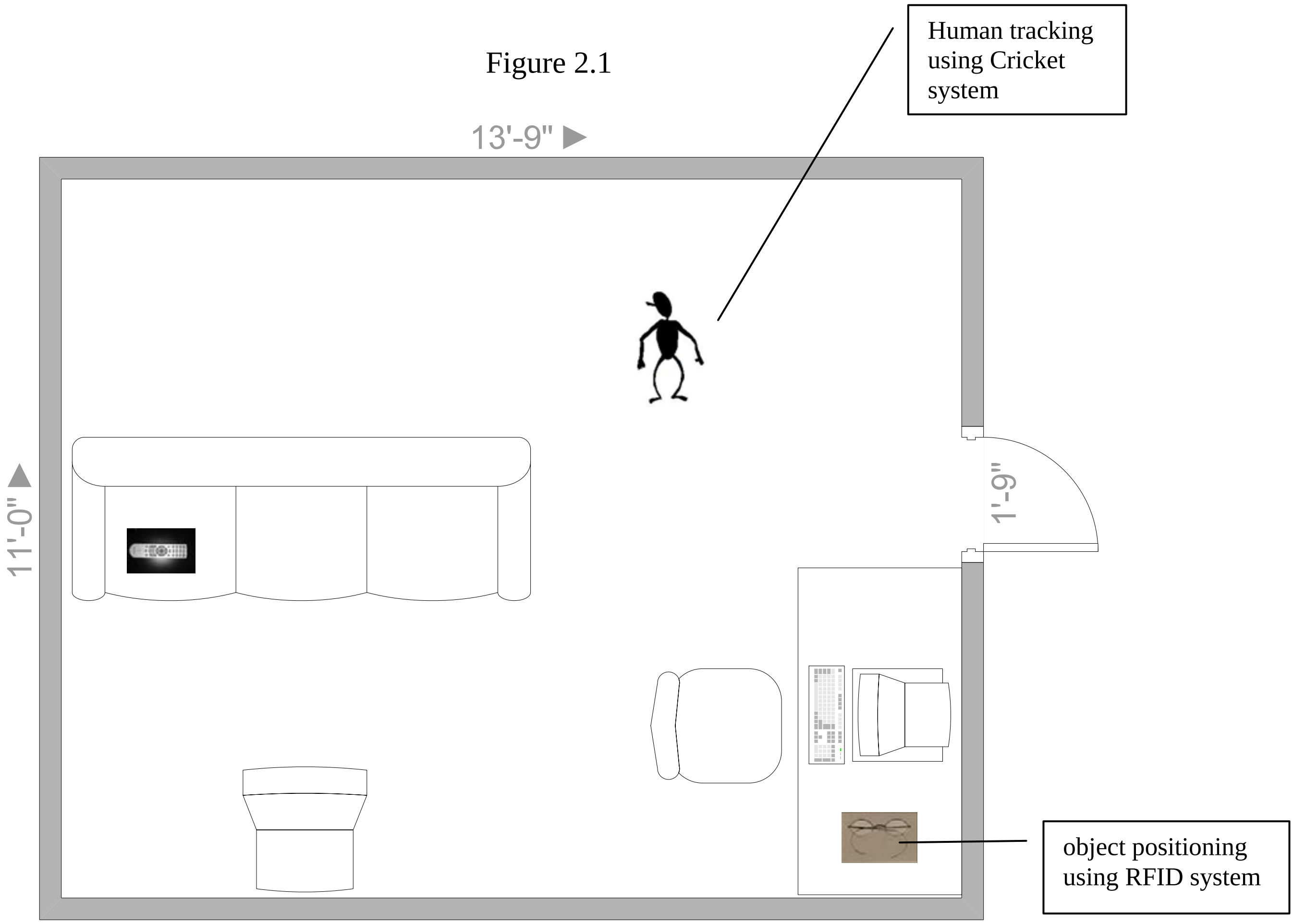

Figure 2.2 system operation

III.Objective:

The main objective of our research is to create a reliable real-time indoor tracking system. This system will be depending on RFID and Cricket technology to achieve a real time tracking, beside we will create our own scheduling algorithm for tracking which will make this system more reliable. Moreover, we will design graphical user interface software which simulates the received data from the RFID and cricket system in graphical way.

IV.RFID subsystem:

Radio frequency identification (RFID) is a system that transmits the identity of an object or person wirelessly using radio waves. RFID system consists of the following components:

4.1 <u>RFID tag:</u>

RFID tag is a small object that can be attached to an object or a person. It contains a small memory and antenna which enable it to respond to RF command from an RFID reader. Each tag has its own unique id which is stored in the memory. There are two kinds of the tags passive and active. The passive tag need to be powered before response to the reader, while the active tags have their own source of power (battery). In our research we have used passive tags from Texas Instrument Company. Figure 4.1 shows an image of a tag from TI.

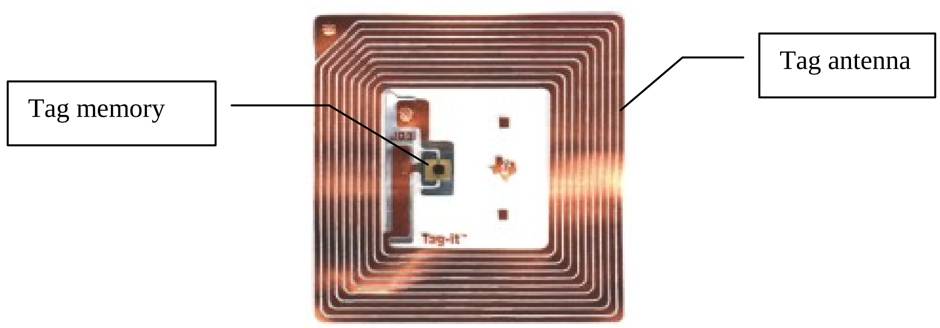

Figure 4.1 Tag-it HF from TI

4.2 <u>RFID reader:</u>

The function of the RFID reader is to send commands to tags and receive responses from them. In our research, we have used M1 and M1-Mini RFID readers from Skyetek. Both readers communicate with a tag using radio frequency 13.56MHz. The M1 reader has a RS232 serial communication port to send and receive command to and from the base station, while the M1-Mini uses a mote to communicate with the base station. Also, both reader can operate with internal antenna with RF range of (3.5 inches for the M1 and 2 inches for the M1-Mini) or an external antenna with RF range of (12 inches for m1 and 7 inches for M1-Mini). Figure 4.2 shows M1and M1-Mini RFID reader.

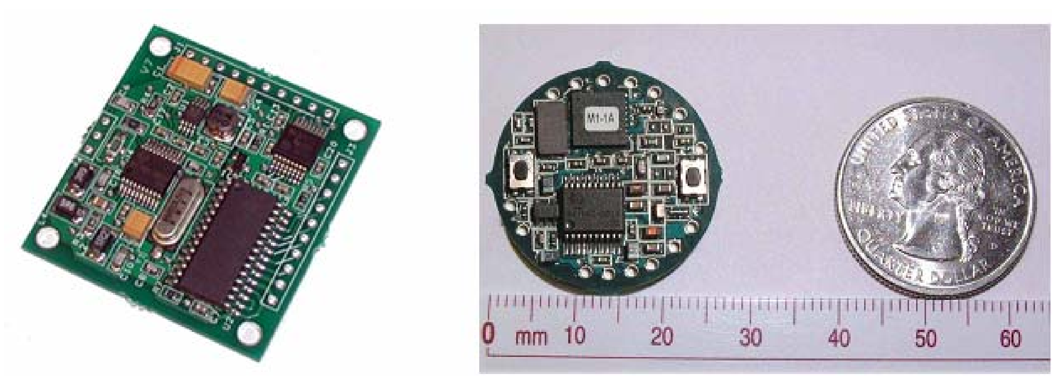

Figure 4.2 M1 Reader to the left and M1-Mini to the right

4.3 <u>MOTE and Base station:</u>

Mote is a wireless transceiver which is attached to RF reader to create a sensing node. The function of the mote is to receive data from RF reader and send it to the base station. Because of the small RF range of the reader, it depends on the mote to deliver the data to the base station. For our work we have used Mica2 and Mica2Dot (for M1-Mini) from Crossbow Company. Figure 4.3 shows the Mica2.

Figure 4.3 to the left Mica2 to the right Mica2Dot

To make RFID system able to send and receive commands from a PC, we have to connect one of the motes (Mica2) to a communication board which will pass command in two ways. For our design we have used MIB510 programmer from Crossbow to connect Mica2 to the PC. The function of the MIB510 is to pass the received data from Mica2 to the PC and pass command from the PC to the Mica2 which in it turns will pass these commands to ant RFID reader in that space, moreover it install nesC codes to the RFID readers. Figure 4.4 shows the MIB510.

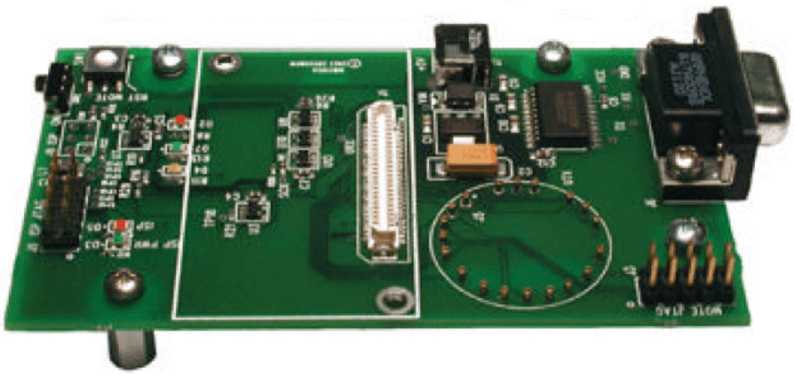

Figure 4.4

4.4 RFID system implementation:

To implement the RFID system, we have used TinyOS as the operating system for the wireless sensor (RFID readers). We used this operating system to write and compile codes in nesC programming language which is a special programming language for wireless sensor networks. Figure 4.5 shows the hardware and the software configuration for the design. For the software configuration, we used TinyOS, which is installed on windows XP, to write and install the nesC code on the Mica2 and Mic2Dot. We create window-based interfacing software which will deliver the command from the laptop to the wireless motes and decode the received information from the wireless motes. For the Hardware configuration, we connect the base station to the laptop using serial link. The laptop sends commands to the base station and the base station will send these commands wirelessly to the sensor nodes. The code which we made for the Mica2 and Mica2Dot will make the two motes communicate with each other to send and receive data that the RF reader pass to them.

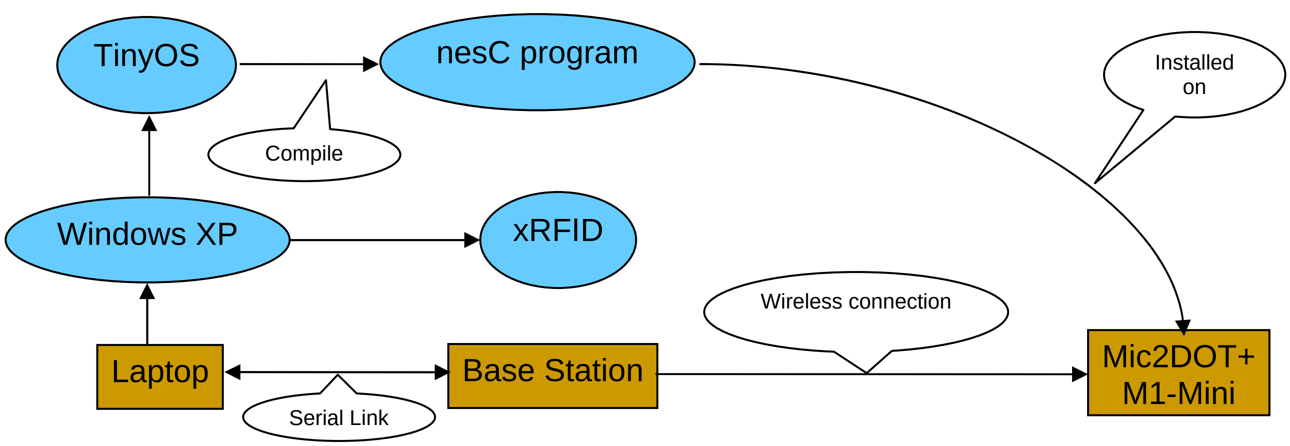

Figure 45. Hardware and software configuration

To understand how RFID system works, we can check figure 4.6 where it presents a read cycle in this system. When a RFID reader powers up it will create a RF field around it self and send a search for tag command to check if there is any tags in its field. The radios of this field depends on the antenna type that we use, in our case it will be 20 inches. Once a tg receives this search command it will response by sending its unique id. The RF reader will use this id to send a read command to that tag. The tag responds by sending the preinstalled data on its memory. The reader receives the data and sends it to the base station where it passes the data to the PC to be analyzed.

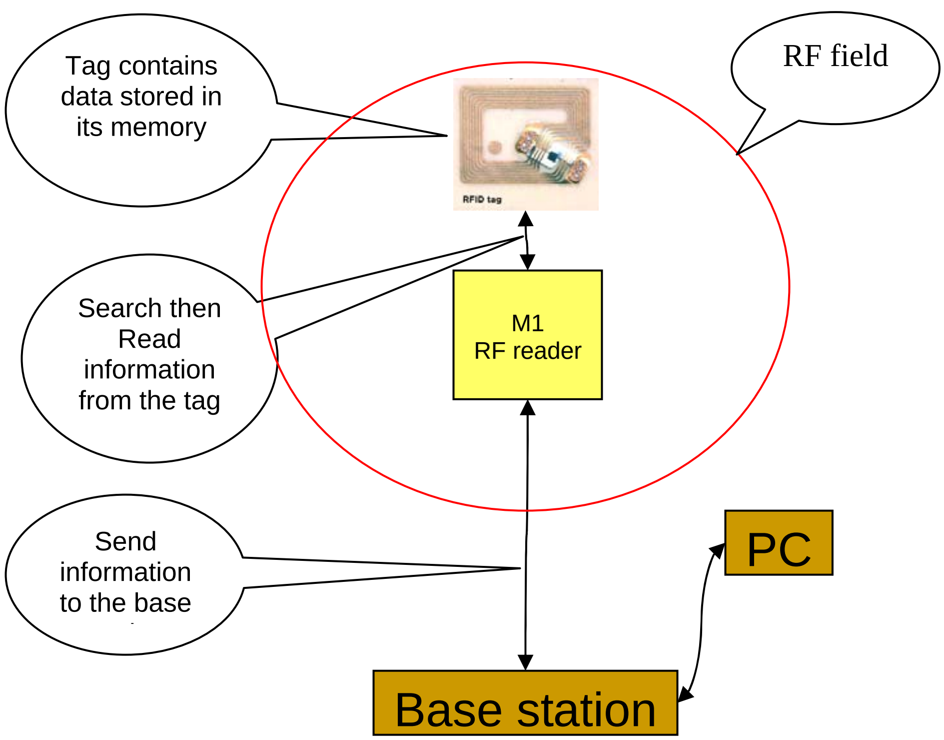

Figure 4.6

4.5 Why RFID for object positioning:

Before taking about the system integration, I will explain why we decide to use RFID for object positioning, and the cricket for the human tracking:

When we implemented our first experiment on the RFID, we found that the tag need some time to be charged by the RF field before it response. So if we used RFID for human tracking any person should wait sometime (15 to 20 ms) for the tag to be charged before it responds to the reader search command. Beside the charged time, the read command needs around 40 ms to be executed which increase the total read cycle to 40+charged time = 55 to 60 ms. This period of time was long for a real time tracking which was of the reasons why we did not choose RFID system for the human tracking. Another reason was the range of the RFID reader. As I said the RF field range for the RFID reader is around 12 inches for the M1. This range imposed that the reader have to be very close to the tag to be able to read it, which we can not guarantee in the real life, and when we tried to increase the number of tags in a small area, we faced a collision problem between the tag's response when more than one tag trying to response at the same time.

V. Cricket subsystem:

Cricket is an indoor location system. It can provide location information such as distance from a known point, a space name and coordinates. The component for this system is just one device called cricket this device can be configured to act as a beacon or listener. Figure 5 shows the cricket device.

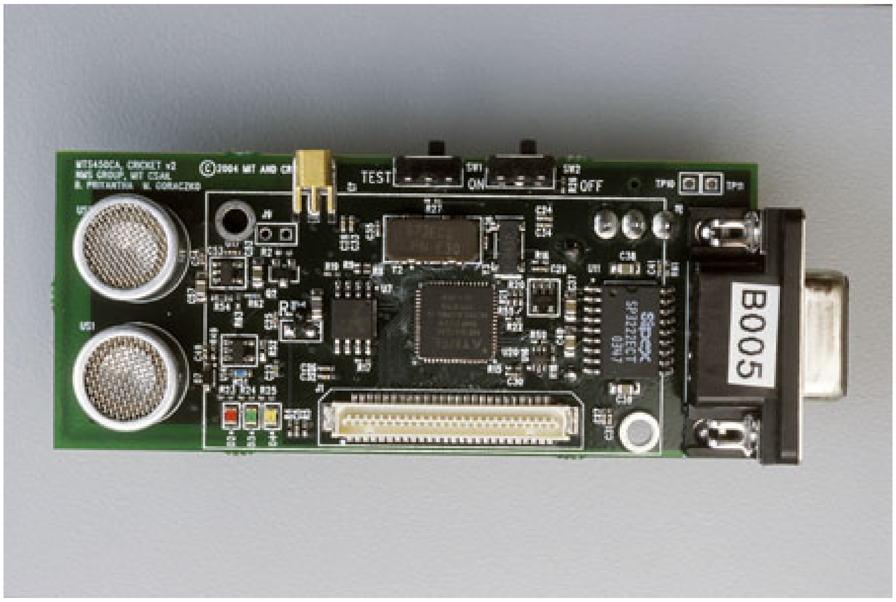

Figure 5

5.1 <u>Beacon:</u>

Beacon is an active device. Its function is to send radio frequency signal (RF) and ultrasound signal (US) at the same time. The RF signal range is around 20 meter, while the US signal range is around 10 meters.

5.2 <u>listener</u>:

Listener is passive device which receives the RF and US signals from the beacon, and uses these signals to calculate the distance between itself and the source beacon which sent these signals.

5.3 <u>Distance calculation:</u>

Distance calculation is done by the listener. When the beacon send RF and US signal at the same time, due to the different in the speed travel the RF will arrive to the listener before the US. Once the listener receives the RF signal it starts a counter to count the time difference between the arrival of the RF and the US. When the listener receives the US, it stops the counter and uses that time to do the distance calculation. Figure 5.1 shows the RF and US signals timing for both the beacon and listener.

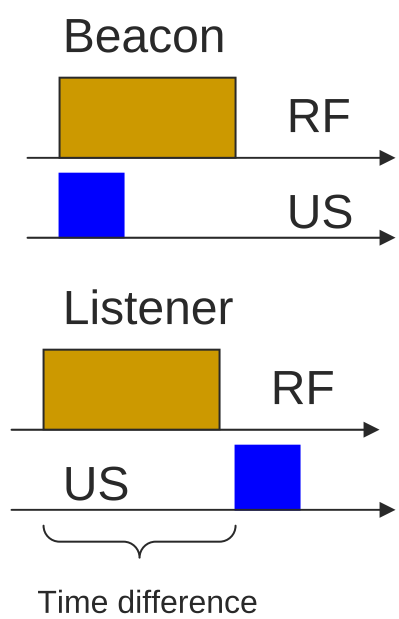

Figure 5.1

5.4 <u>Cricket system implementation:</u>

For the implementation of the cricket system, we have configured on cricket as a beacon and other cricket as a listener. Once the beacon starts, will keep sending RF and US signals creating a RF field and US field around itself, as shown in figure 5.2.

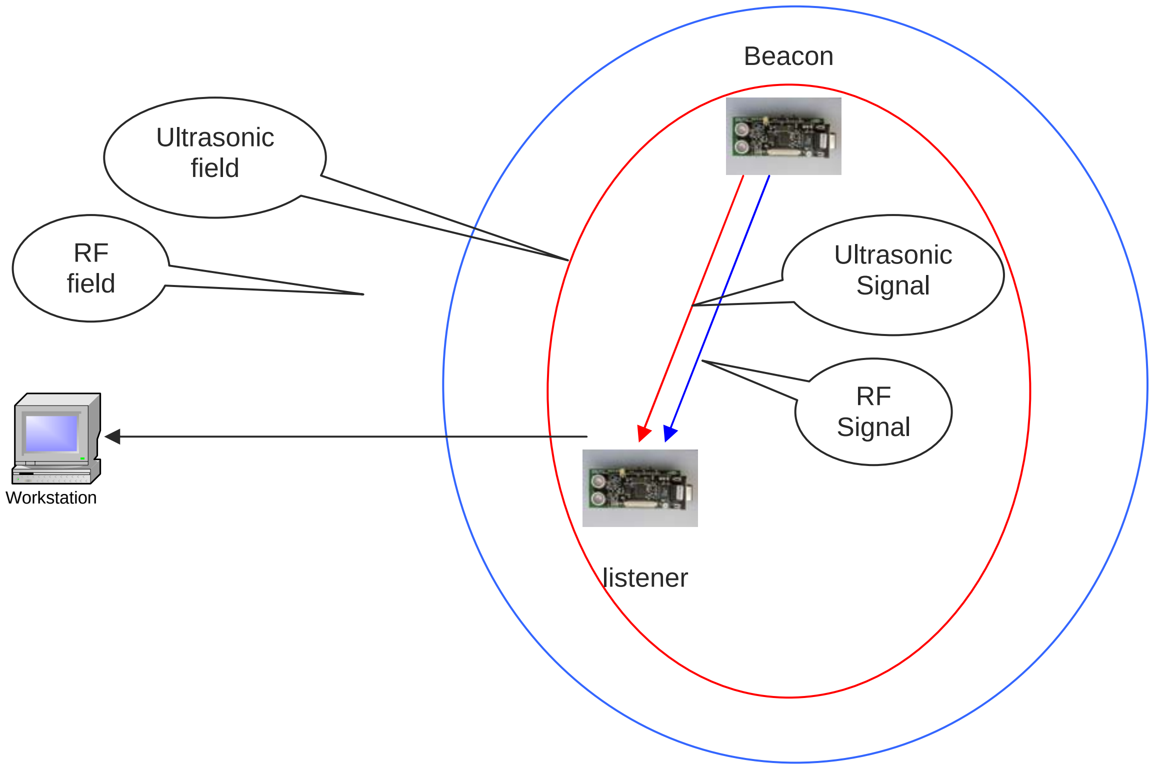

Figure 5.2

When a listener enters the RF and US fields of the beacon, it will receive the RF signal first and then the US signal. Once this done, the listener will calculate the distance between itself and the source beacon and send this calculation to the PC.

For the PC to infer the position of the listener, it has to accumulate at least three different distances from three different beacons, because to pin out the position of a listener inside a room less than three distances from three different beacons will not help in doing our calculation to infer the position of the listener. So, when the PC receives the three distances it will do some calculation to infer the position of the listener.

VI.Graphical user interface software:

The main propose of the GUI is to provide the user with an easy to use interface. This interface will allow the user to watch a live tracking of the movement of anyone who is carrying a listener; also it will help the user to find the position of a lost object by just clicking on the picture of this object. The software will use a database where it will keep all the received data from the base station. This database will act as a record of any person of object movement or change of position, so we cab use this database to go back in time and check the last activity of a person or the previous position of an object.

To do this code I used Visual C++.net to write the software code, and I used SQL database to mange and control the input of the data into our database.

Figures 6.1 and 6.2 show the live tracking screen and object positioning screen respectively. In figure 6.1 the live tracking screen the start button will start receiving data from the base station and update the position of any person (who is carrying a listener) on the screen map, also it will passes the received data to our database to be stored. The Listener Data box on the main screen will always gives the coordinate(X, Y, Z) of the tracked target, so we can know the exact position of this person or object by just looking at this box.

The “where is my…?” button will activate the object position which will lead us to figure 6.2.

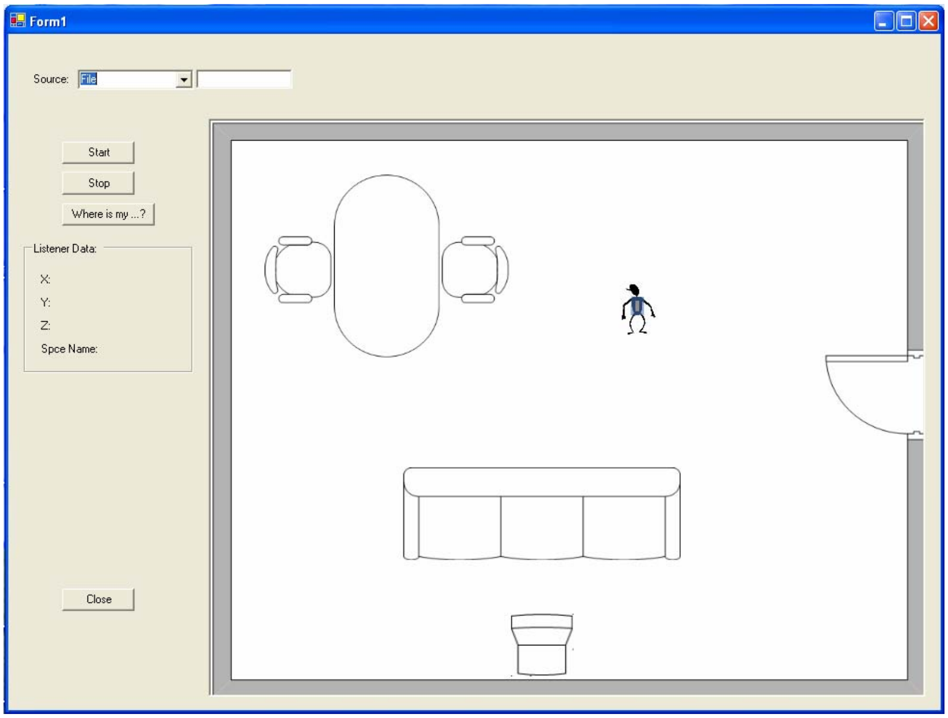

Figure 6.1 live tracking screen

In figure 6.2, we can see the object buttons. Each button represents an object with the tag in the room. If a user needs to know the position of an object he/she will just click on the object button with the proper picture and the position of the object will appear on the room map, beside a text message will appear on the side telling the user in which room this object is located.

The data about the object position will be also stored in the database, so although the object new position does not appear on the map, this position will be stored in the database as soon as we received from the base station. So whenever a user click the object button, the screen will display the recent position of the object we have received from the base station.

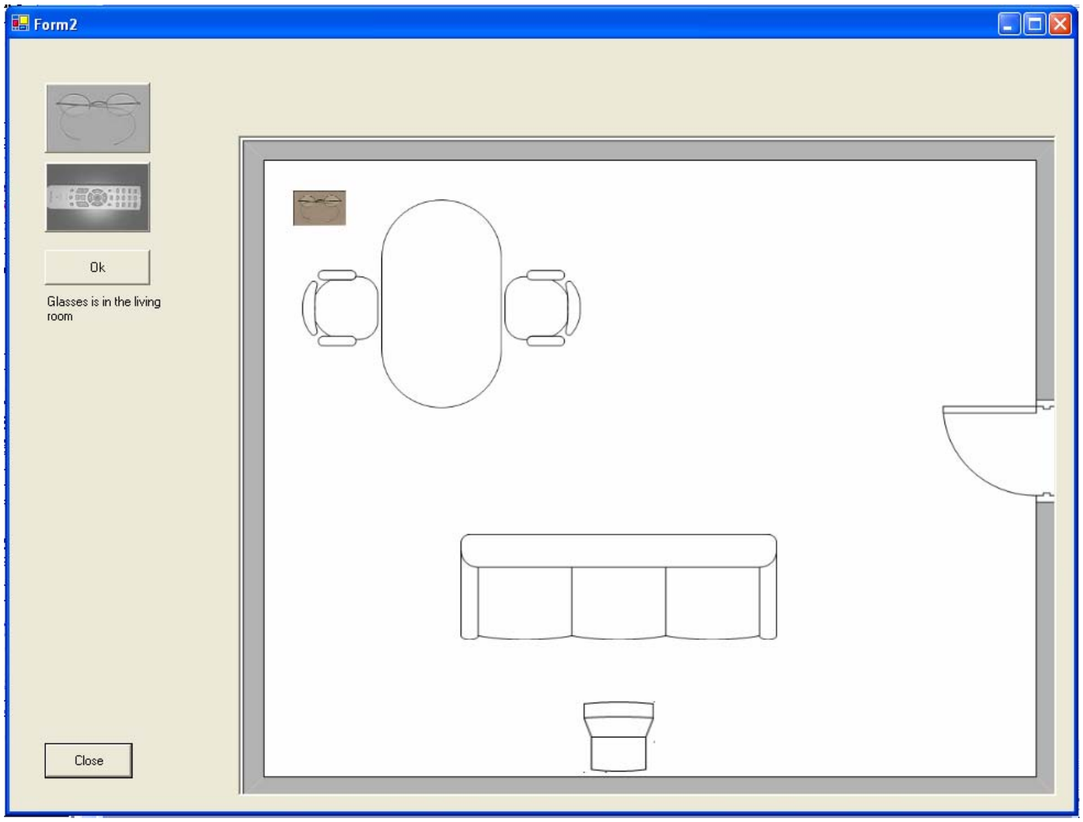

Figure 6.2

VII.System integration:

As I said in the beginning of this paper, the previous discussed subsystems were integrated together to achieve our system. So the integration of these subsystems was as follows:

For the human tacking we have used the cricket system. We have configured one cricket to act as a listener and other three crickets to be beacons. For the object positioning, we used M1 reader where we connect the serial port of the M1 to the listener serial port and made the listener send the search command to the M1. To identify each object we associate each tag id with an object, so when a RF reader sends a search command, it will receive the tag id which we will use to identify this object. After receiving the tag id the listener will include the received id with the distance calculation, which is already done by the listener, and send these data to the base station. The base station using Mica2 and MIB510 will receive the data and passes to the GUI. The GUI will get the data and simulate the result on the screen and pass it to the database. Figure 7 summarize this operation.

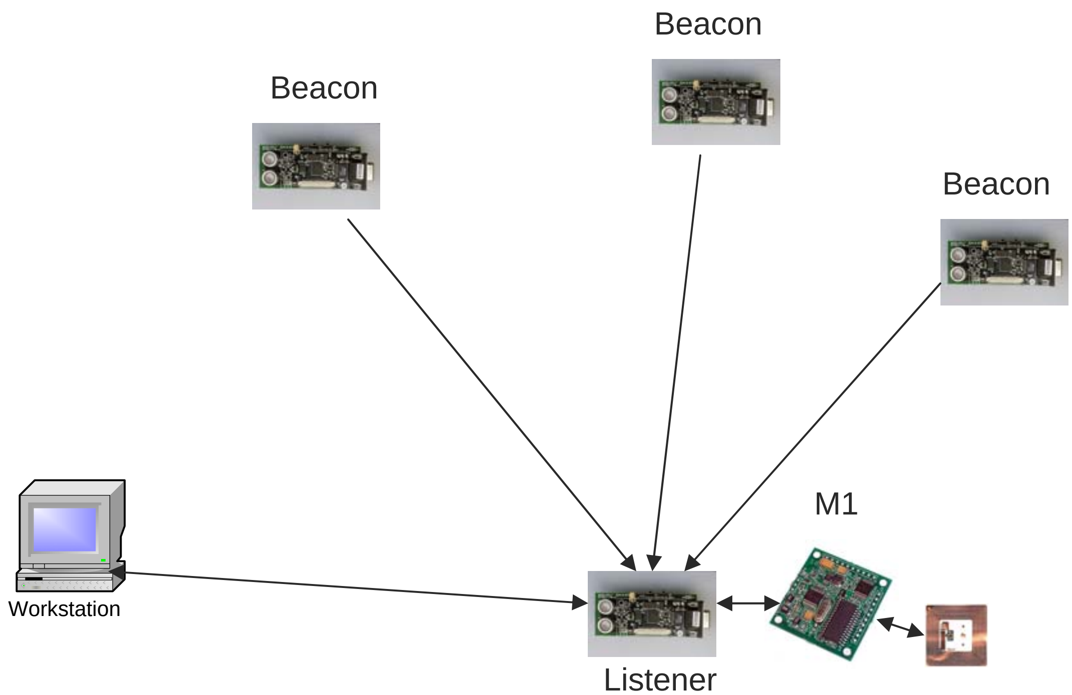

Figure 7

VIII.Conclusion:

The objectives of this research were successful. We were able to track a listener movement and make the RFID reader communicate with the listeners. And make the GUI receive this information and display it on the screen. Now we are working on making the received result more accurate by performing several algorithm to improve the cricket system and the RFID system, at the same time, we are working on make the GUI reduce the error we are receiving from the base station by performing some correcting algorithms.